How to attack (and secure) an Android app: An introduction

Caner Kaya
Security Software Engineer

caner.kaya@promon.no

Who am I

- **Expertise:**
  - Android Security
  - Reverse Engineering
  - Vulnerability Analysis
  - Malware Analysis
- **Hobbies:**
  - Mountain Biking 🚵
  - Snowboarding 🏂
- **Mission:** Securing Apps & Shredding Slopes!
- **Motto:** "I code with one hand, hack with the other, and balance on two wheels in between!"

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Introduction

- What is this workshop about?
  - Showing the view of an attacker.
  - Mostly practical demonstrations.
  - Discussion of countermeasures.
- Material: https://github.com/pplithium/tekna

Reverse engineering

- Understanding how an app works.
- Reveal secrets in it.
- First step of an attacker.
- Two complementary approaches: Static and dynamic
- On Android
  - Java code (Java, Kotlin)
  - Native code (C, C++, Dart, …)

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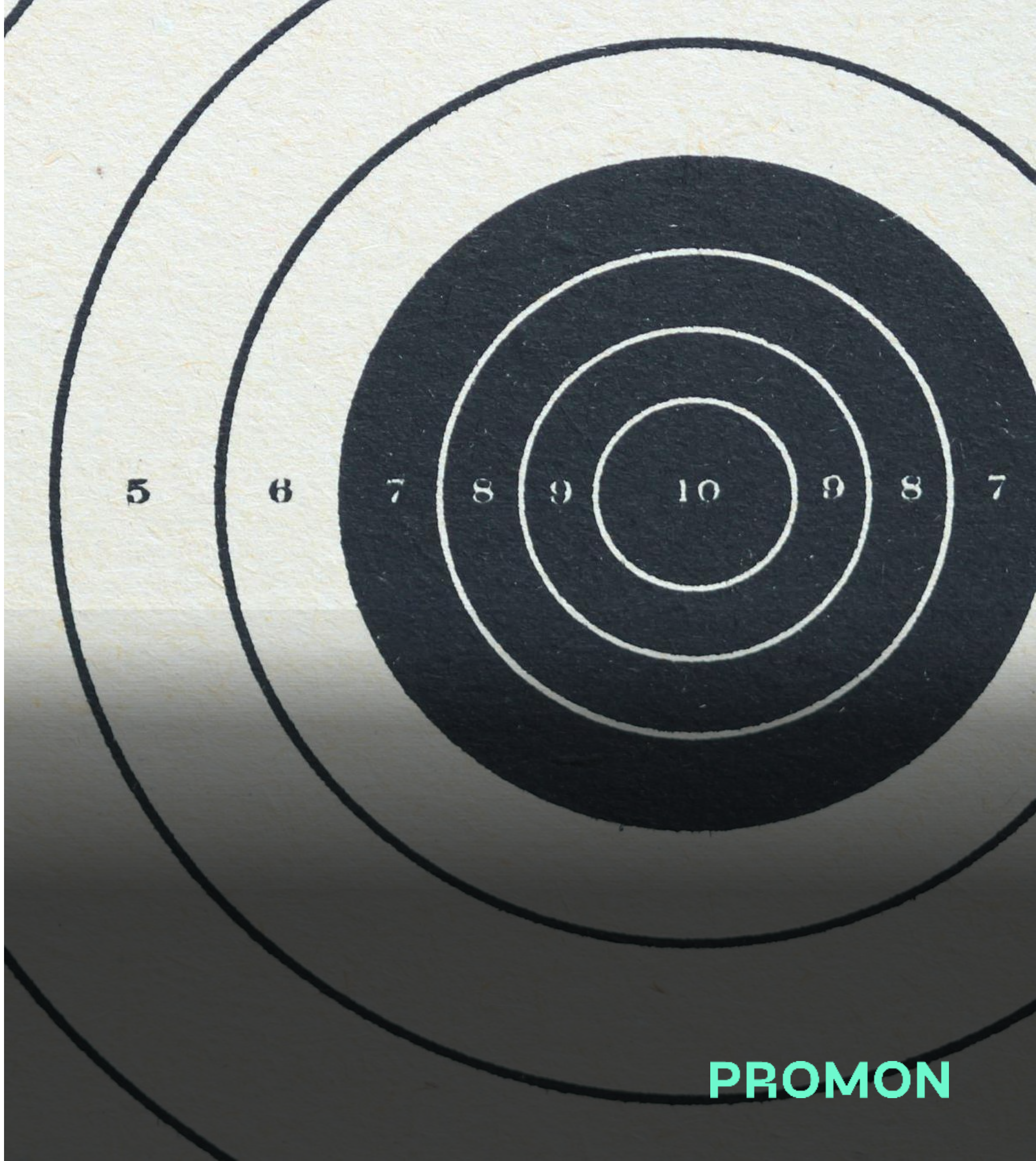
Reverse engineering Java code

- **Code in classes.dex file(s).**
- **Dalvik bytecode executed in VM.**
- **Requires disassembler[1] or decompiler[2].**

[* https://github.com/skylot](https://github.com/skylot)
[* https://github.com/iBotPeaches/Apktool](https://github.com/iBotPeaches/Apktool)

Demo



Protecting against reverse engineering

- Impossible to prevent.
- Obfuscation can make it harder.
- Some things you can do
  - Rename/remove identifiers.
  - Encrypt strings.
  - Use reflection.
  - Use native code.
- Ideally done with a tool[1,2,3,4,5].

- 1 https://r8.googlesource.com/r8
- 2 https://www.guardsquare.com/proguard
- 3 https://github.com/obfuscator-llvm/obfuscator
- 4 https://obfuscator.re/omvll
- 5 https://obfuscator.re/dprotect

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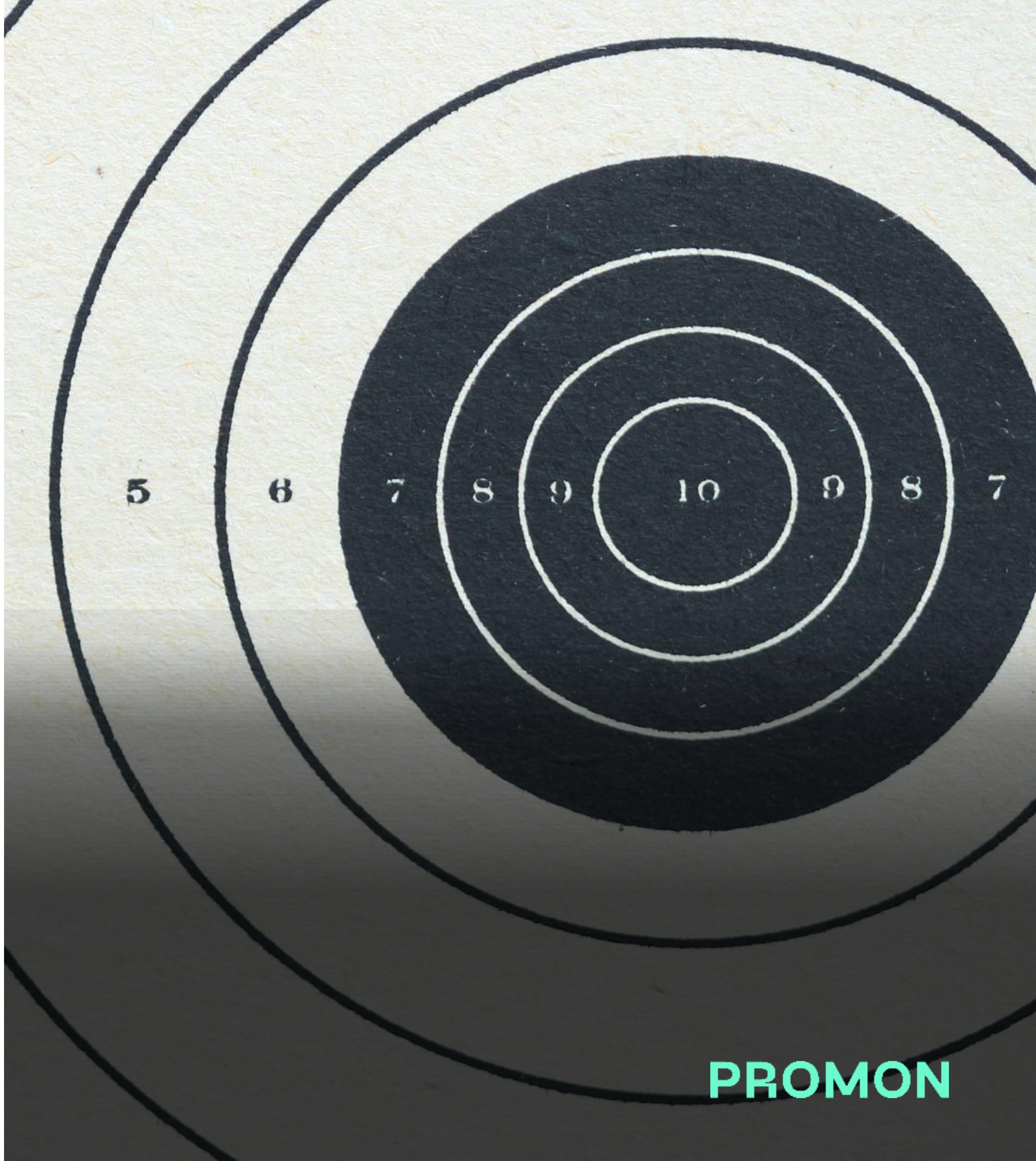
Repackaging

1. Modifying app on disk.
2. Change code to change behavior.
3. Change resources to change look.

Patching Java code

- Modify classes.dex file(s).
- Direct binary patching can be tricky.
- Tools like apktool make this easy
  - Disassemble to smali.
  - Modify smali.
  - Re-assemble to apk.

Demo



A real scenario – Introduction

- A company for door systems vulnerable in both app and the door computer
- We had reverse-engineered our way into the building.

  - Reverse engineered the application.
  - Repackaged the application and tracked the communication.
  - Instrumented the communication on our fake application, and added our NFC tags for free entrance.

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A real scenario – Part 1

We have firstly analyzed the apk to find the NFC channels used (*mAID*). It was quite openly shown in the code.

```
.line 166
const/4 v1, 0x1

new-array v1, v1, [Ljava/lang/String;

const/4 v2, 0x0

const-string v3, "4E45574754"

aput-object v3, v1, v2

invoke-static {v1}, Ljava/util/Arrays;->asList([Ljava/lang/Object;)Ljava/util/List;

move-result-object v1

.line 167
iget-object v2, p0, Ljp/co/aiphone/ngt_android_setting_tool/NFCCommunicationActivity;->A:Landroid/nfc/cardemulation/CardEmulation;

const-string v3, "other"

invoke-virtual {v2, v0, v3, v1}, Landroid/nfc/cardemulation/CardEmulation;->registerAidsForService(Landroid/content/ComponentName;Ljava/lang/String;Ljava/util/List;)Z
```

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A real scenario – Part 2

- With the NFC Channel, we attempted to communicate with the NFC based door system.
  Door system:
   - there must be a management system with an admin user for managing
   - there must be the 'normal users' for openning the doors
- We have first tried brute forcing the admin password:

A real scenario – Part 3

- After finding the admin password with a brute force attack, we attempted to send our 'fake' NFC tags to attempt to inject them into the door system database.
- However, things weren't as easy as it was until now.
- To solve the problem, we have injected a logger method between the original app after repackaging it, and we recompiled it to watch the communication.

A real scenario – Part 3

```
.method public logMe(Ljava/lang/String;)V
    .registers 4
    .param p1, "str"    # Ljava/lang/String;
    .annotation system Ldalvik/annotation/MethodParameters;
        accessFlags = {
            0x0
        }
        names = {
            "str"
        }
    .end annotation

    .line 384
    new-instance v0, Ljava/lang/StringBuilder;

    invoke-direct {v0}, Ljava/lang/StringBuilder;-><init>()V

    const-string v1, "comm: "

    invoke-virtual {v0, v1}, Ljava/lang/StringBuilder;->append(Ljava/lang/String;)Ljava/lang/StringBuilder;

    move-result-object v0

    invoke-virtual {v0, p1}, Ljava/lang/StringBuilder;->append(Ljava/lang/String;)Ljava/lang/StringBuilder;

    move-result-object v0

    invoke-virtual {v0}, Ljava/lang/StringBuilder;->toString()Ljava/lang/String;

    move-result-object v0

    const-string v1, "NFC_COMMAND"

    invoke-static {v1, v0}, Landroid/util/Log;->d(Ljava/lang/String;Ljava/lang/String;)I

    .line 385
    return-void
.end method
```

```
.method public processCommandApdu([BLandroid/os/Bundle;)[B
    .registers 11
    .param p1, "commandApdu"    # [B
    .param p2, "extras"    # Landroid/os/Bundle;
    .annotation system Ldalvik/annotation/MethodParameters;
        accessFlags = {
            0x0,
            0x0
        }
        names = {
            "commandApdu",
            "extras"
        }
    .end annotation

    .line 149
    new-instance v0, Ljava/lang/String;

    sget-object v1, Ljava/nio/charset/StandardCharsets;->US_ASCII:Ljava/nio/charset/Charset;

    invoke-direct {v0, p1, v1}, Ljava/lang/String;-><init>([BLjava/nio/charset/Charset;)V

    .line 151
    .local v0, "s":Ljava/lang/String;
    invoke-static {p1}, [redacted]/services/GTHostApduInjectorService;->bytesToHex([B)Ljava/lang/String;

    move-result-object v1

    invoke-virtual {p0, v1}, [redacted]/services/GTHostApduInjectorService;->logMe(Ljava/lang/String;)V
```

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A real scenario – Summary

- We have developed an application that does the exact communication for adding and removing the users.
- We extended this attack as an application to:
  - Find the admin code
  - Add the hacker user (NFC Tag)
  - Enter to the building
  - Remove the user
  - Clear all the traces

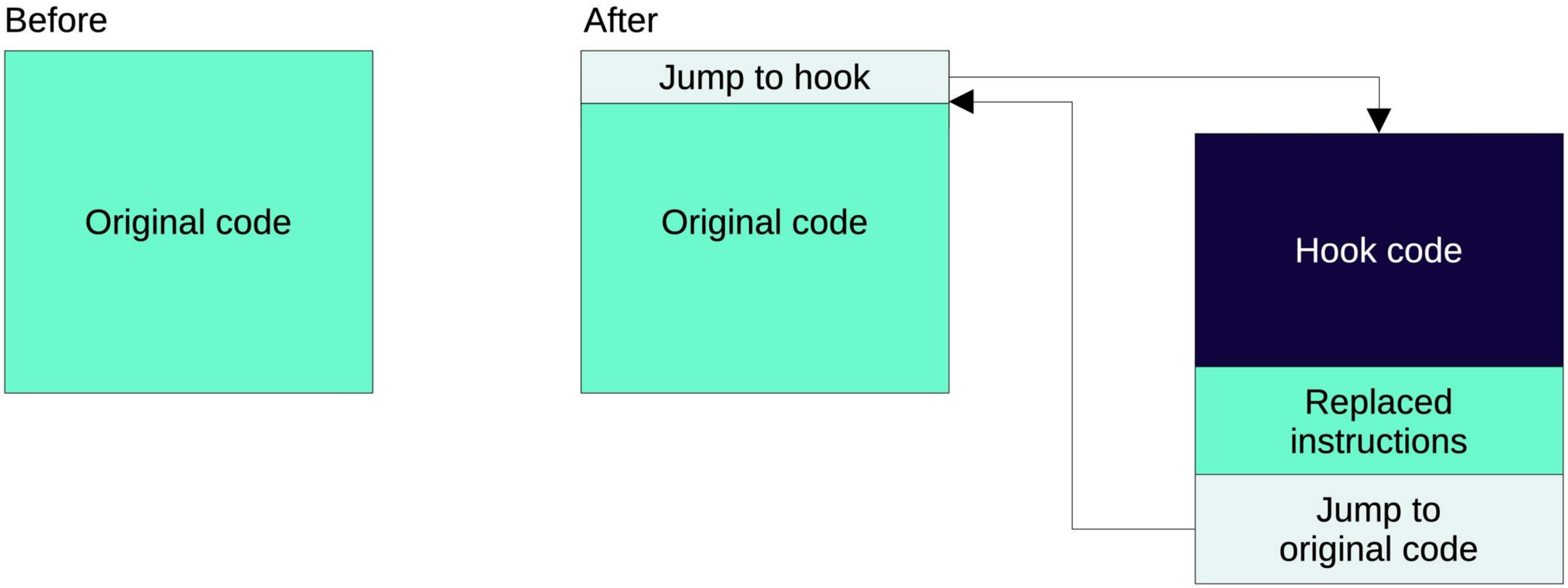
Protecting against Repackaging

- Implement anti-tampering mechanisms
  - Check APK signature and signer.
  - Implement checksumming mechanism.
- Can also be patched.
- Obfuscation can make this more difficult.
- Multiple independent mechanisms can make this more difficult.

Hooking

- Modify the app while it runs.
- Change code to change behavior.
- Useful for dynamic reverse engineering.

How hooking works



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Hooking Java code

- **Code is executed in VM.**
- **Could be compiled ahead of time or just in time.**
- **Requires modifying the VM.**
- **Popular hooking frameworks**
- LSPosed
- Frida

Hooking native code

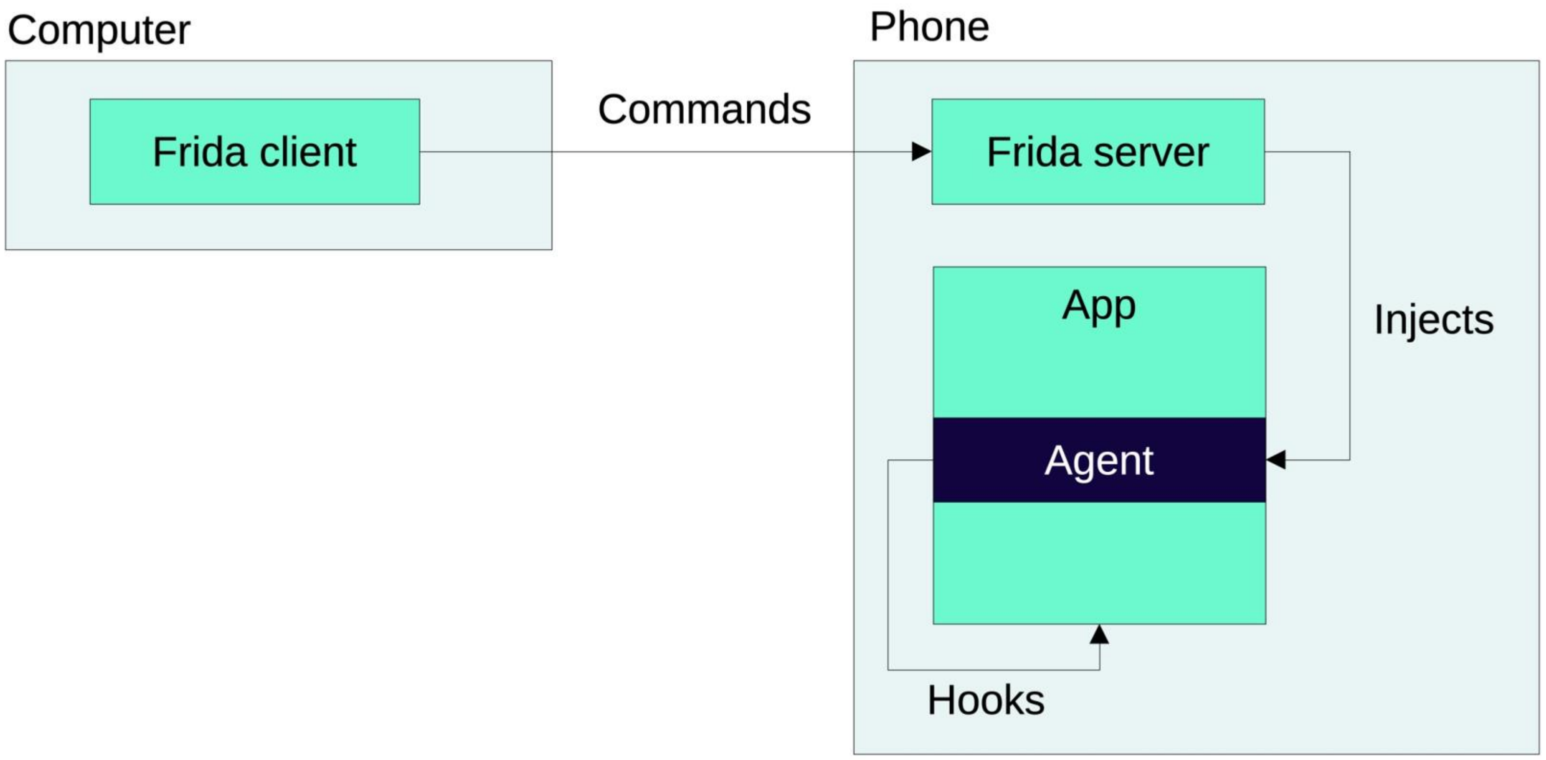
Overwrite code in memory.

Not completely trivial.

Frida is a popular framework to use.

FRIDA

How Frida works in our use case



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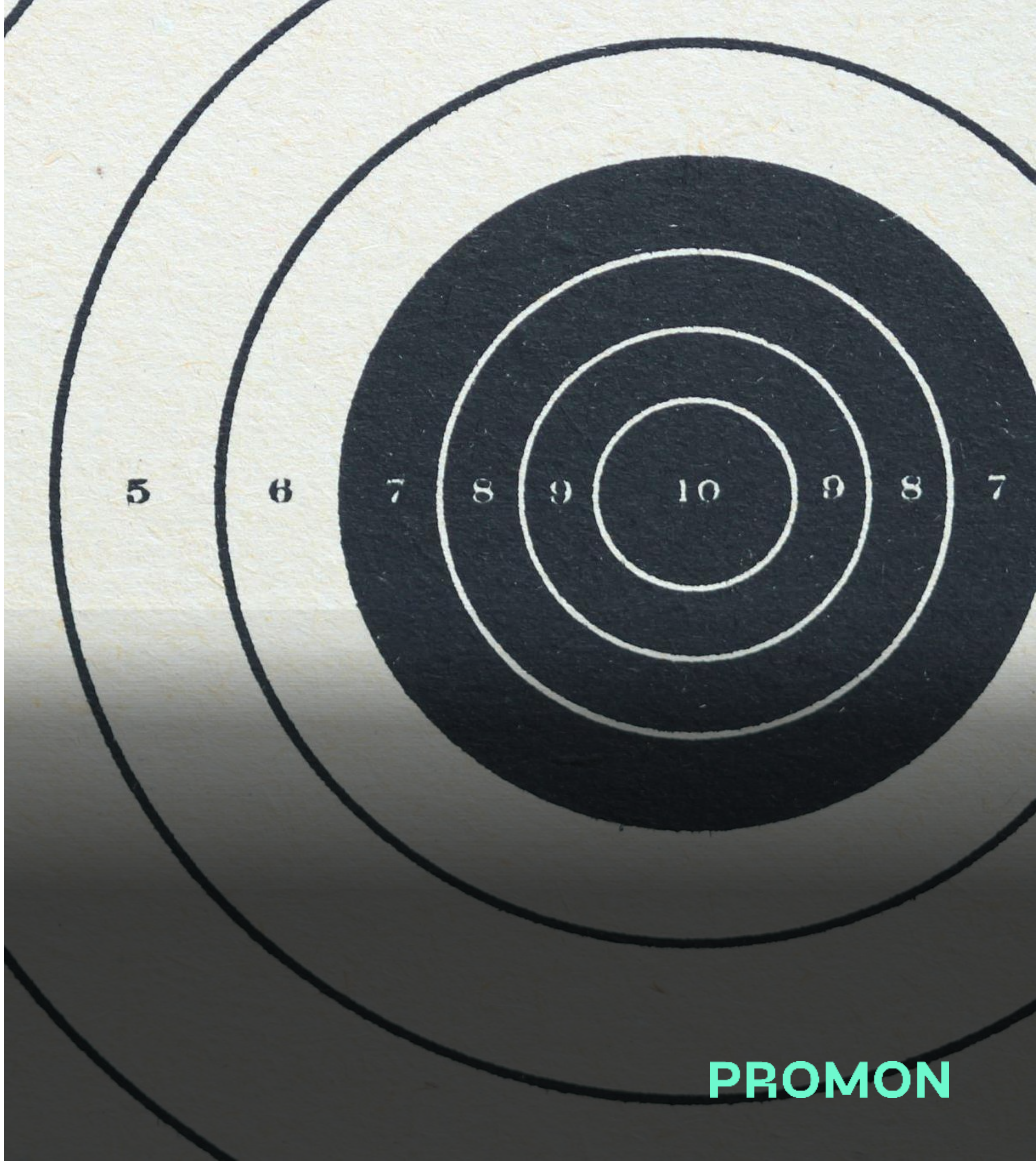
Demo



Protecting against Hooking

- Detect hooks
  - Check for code modifications in memory.
- Detect hooking framework
  - Check for suspicious files, libraries and communication channels.
- Can also be hooked.
- Obfuscation and multiple independent mechanisms make it harder.

Strandhogg

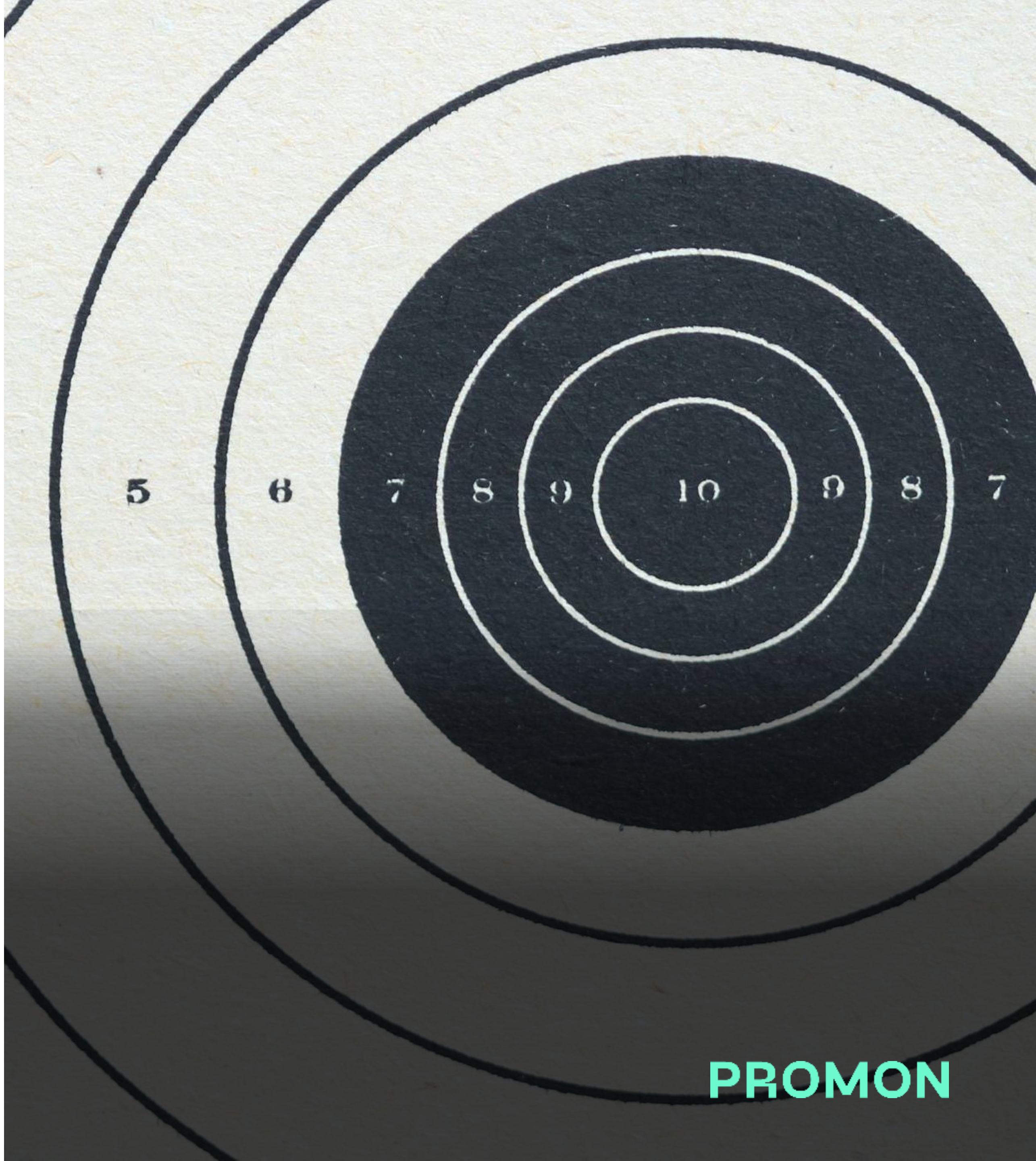
- Strandhogg Attack has been discovered in 2019
- Niche
- Identified *non-disclosed* amount of malicious apps in the wild
- It uses taskAffinity attribute, and gets injected into another app's Task*(1)

https://developer.android.com/topic/security/risks/strandhogg

Strandhogg

- What means Task* in this context?

Demo



Summary

- Is this a problem for you?
- Possible to implement countermeasures yourself.
- Better than doing nothing but probably not too effective.
- It might be worth considering getting help.

Thank you!

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